TITLE OF INVENTION

Backlight Display System

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] Not Applicable

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] Not Applicable

BACKGROUND OF THE INVENTION

1. Field of Invention

[0003] This invention pertains to backlighting translucent images. More particularly, this invention pertains to apparatus and methods for integrating a lighting circuit on a glass substrate to provide backlight illumination of a transparent and/or translucent image.

2. Description of the Related Art

[0004] The use of fluorescent light to backlight or illuminate a color transparency is well known in the art. In a typical embodiment, fluorescent bulbs are placed within a box having a glass front panel to which a color transparency is secured. Typically, such an arrangement requires that the box containing the fluorescent bulbs be deep enough to prevent the bulbs from forming hotspots or brighter areas on the transparency.

[0005] Various patents have issued with respect to backlighting images. For example, United States Patent Number 3,748,455, titled "Display Apparatus," issued to Welton on July 24, 1973, discloses a portable display apparatus for exhibiting at a trade show. The Welton device includes a light box having a removable translucent or transparent panel and folding doors or panels, which make the light box self-supporting. An improvement of the Welton device is

disclosed in United States Patent Number 4,602,448, titled "Lighted display panel system," issued to Grove on July 29, 1986. The Grove patent discloses a lighted display panel system that distributes fluorescent light through a lens over the lamps, thereby reducing the depth of the light box and avoiding hot spots.

[0006] As seen by the above identified patents, it is often quite useful to be able to place a light source on or very close to the surface of a glass substrate. Such applications include mounting lights in the vicinity of vanity mirrors for use in automobile visors. For example, United States Patent Number 5,162,950, titled "Lighted Mirror Assembly for Motor Vehicle Visor," and issued to Suman, et al., on November 10, 1992, discloses an illuminated vanity mirror assembly with a resistor screen-printed on a polymeric film substrate glued to the back face of the mirror.

[0007] Various apparatus and methods for integrating electrical circuitry onto a substrate are known. Additionally, various techniques are known for making electrical connections to components mounted on the substrate. For example, United States Patent Number 4,081,601, titled "Bonding Contact Members to Circuit Boards," issued to Dinella, et al., on March 28, 1978, discloses a conductive overlay solder-bonded over a contact finger top surface area and having a gold surface layer. United States Patent Number 5,019,944, titled "Mounting Substrate and Its Production Method, and Printed Wiring Board Having Connector Function and Its Connection Method," issued to Ishii, et al., on May 28, 1991, discloses using metal nodules and adhesive to make electrical contact and to mount components to a substrate.

BRIEF SUMMARY OF THE INVENTION

[0008] Apparatus and methods for backlighting a transparent and/or translucent image are provided. According to one embodiment of the present invention, at least one polymer thick film conductive strip is applied to a glass substrate, connecting at least one light emitting device, a dropping resistor, if required, and a power supply connection. The glass substrate is position behind a translucent image that is illuminated by the light emitting devices. A back board is

behind the glass substrate. The back board has a reflector facing the glass substrate and a plurality of spacers for separating the back board from the glass substrate. In one embodiment, light barriers are positioned between the back board and the glass substrate. In another embodiment, a frame encloses a sheet with the translucent image, the glass substrate, and the back board.

[0009] The method of fabricating the glass substrate with the electrical circuit on one surface, in one embodiment, includes the steps of preparing the substrate, applying and curing an opaque border with thermosetting paint to one side of the substrate, applying at least one conductive trace to a specified area of the one surface of the substrate, applying a component adhesive to the substrate, applying the electrical components of the substrate, and curing the circuit on the substrate.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0010] The above-mentioned features of the invention will become more clearly understood from the following detailed description of the invention read together with the drawings in which:

Figure 1 is an exploded view of one embodiment of the present invention;

Figure 2 is a plan view of one embodiment of the glass plate;

Figure 3 is a schematic diagram of one embodiment of the present invention;

Figure 4 is a schematic diagram of another embodiment of the present invention; and

Figure 5 is a schematic diagram of still another embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0011] An apparatus for backlighting a transparent and/or translucent image is disclosed. Although the illustrated embodiment of Figure 1 shows a frame

102, such as a common picture frame, the backlight image system **10** is suitable for other applications in which an object is illuminated from the rear.

[0012] Figure 1 illustrates a backlight image system **10** in an exploded view. A translucent sheet **104** is adapted to be inserted in a frame **102**. Behind the translucent sheet **104** is a glass plate **106**. Behind the glass plate **106** is a back board **108**, which is separated from the glass plate by standoffs, or spacers, **134**. In another embodiment, the frame **102** is constructed such that separate spacers **134** are not required because the frame **102** provides for supporting the glass plate **106** away from the back board **108**.

[0013] The translucent sheet **104** has an image **112** printed or otherwise affixed to the sheet **104**. In one embodiment, the translucent sheet **104** is a backlight film having a glossy finish on the front and a matte finish on the back upon which the image is printed in reverse. In the illustrated embodiment, the area taken by the image **112** is less than the full area of the sheet **104** to allow for the backlighting and the border created by the frame **102**. The image **112** is any graphic or other image. In various embodiments, the image **112** is formed by printing on the surface of the translucent sheet **104** with an ink jet or laser printer. In another embodiment, the translucent sheet **104** has multiple images **112** and the sheet **104** scrolls such that each image **112** is illuminated in turn.

[0014] In another embodiment, the translucent sheet **104** is a transparency film with an image **112** on one surface. In still another embodiment, the translucent sheet **104** is a cloth or fabric. In various other embodiments, other materials that produce an effect when illuminated from the rear are used in place of the translucent sheet **104**.

[0015] The back board **108** is a stiff board upon which one surface a reflector **132** is formed. In one embodiment, the reflector **132** is a white surface surrounded by a black surface on the back board **108**. In another embodiment, the reflector **132** is a mirrored surface. The reflector **132** is sized to match the opening bounded by the light emitting devices **126** on the glass plate **106**. The black border on the back board **108** reduces the occurrence of hotspots.

[0016] The back board **108** includes an opening **136** through which the power connector **124** is accessible. In the illustrated embodiment, the back board **108** includes a plurality of spacers **134**. The spacers **134** are positioned so as not to interfere with the light emitting devices **126**, either by coming into contact with the light emitting devices **126** or by obstructing the light emitting devices' **126** emitted light path. In one embodiment, the spacers **134** are a resilient material that secure the glass plate **106** in the frame **102**. In various embodiments, the spacers **134** are formed of foam, rubber, or other resilient or compressible material. In another embodiment, the spacers **134** are spring-type devices that function to separate the back plate **108** from the glass plate **106** and to secure the glass plate **106** in the frame **102**. In still another embodiment, the frame **102** is constructed in such a manner as to secure the glass plate **106** at the front of the frame **102** and to secure the back plate **108** at the back of the frame **102**. In one embodiment, the frame **102** includes protruding tabs to secure the glass plate **106** and the back plate **108**.

[0017] In one embodiment, the light emitting devices **126** are light emitting diodes (LEDs). In another embodiment, the light emitting devices **126** are incandescent lamps. As used herein, light emitting devices **126** includes both LEDs, incandescent lamps, and other sources of electrically driven illumination.

[0018] Figure 2 illustrates the back surface of the glass plate **106**. The glass plate **106** is a transparent sheet of glass that is positioned behind the transparent and/or translucent sheet **104**. In another embodiment, the plate **106** is formed of a material other than glass. The material being suitable for holding the illumination circuit to its surface. In the illustrated embodiment, the plate **106** is transparent. In another embodiment, selected portions of the plate **106** are coated with an opaque material, thereby preventing the transfer of light from the light sources **126** to the transparent and/or translucent sheet **104** in the selected portions.

[0019] In the illustrated embodiment, a coaxial power connecter receptacle **124** is electrically connected to conductor traces **128** on the glass plate **106**, which

is a substrate to which the illumination circuit is attached. The conductor traces **128** form conductors that connect the various electrical components **124**, **122**, **126** mounted on the glass plate **106**. The conductor traces **128** are formed by applying a conductive polymer thick film ink with specified properties to the glass plate **106**. Generally, polymer thick film inks are screen printable resins that include conductive fillers, such as silver, copper, and other conductive materials (for a conductive polymer thick film ink), resistive fillers, such as carbon, (for a resistive polymer thick film ink), or no fillers (for an insulating polymer thick film ink). The properties of the polymer thick film ink include, but are not limited to, electrical conductivity. Typically, these properties are varied by changing the materials in the ink. For example, the conductive traces **128** require high electrical conductivity; therefore, an ink with copper, silver, or other conductive material is used, with silver producing an ink with higher electrical conductivity than copper.

[0020] Polymer thick film ink has other properties, including viscosity, which determine the method of application. Selecting the viscosity and other properties for a particular method of application is known in the art. Those skilled in the art will recognize that any of various conductive inks can be used without departing from the spirit and scope of the present invention.

[0021] In the illustrated embodiment, the circuit formed by the conductor traces **128** connects the power connector to a dropping resistor **122** and to the four LEDs **126A**, **126B**, **126C**, **126D**. The dropping resistor **122** serves to limit the current flowing through the LEDs **126**. In one embodiment, the dropping resistor **122** is a surface mount resistor electrically connected to the conductor traces **128**. In another embodiment, an ink with carbon is used for the resistor **122**. In this embodiment, instead of using a surface mount resistor, a strip of resistive polymer thick film ink is used. The electrical conductivity, or inversely, the resistivity, of the ink is controlled by adjusting the amount of conductive material in the ink. The resistive strip **122** requires a lower electrical conductivity than the conductive traces **128**; therefore, an ink with carbon is used, with the amount of carbon used

controlling the conductivity. In this embodiment, the resistive ink is a low-ohm carbon ink.

[0022] In the illustrated embodiment, the light emitting devices **126** are positioned in the corners of the glass plate **106** with the light emitting portion **202** aimed toward the center of the glass plate **128** with the radiating axis of the light being parallel to the glass plate **106**. In another embodiment, the light emitting devices **126** are located at places other than the corners of the glass plate **106**, thereby producing special effects on the image **112**. In one embodiment, the light emitting devices **126** are high intensity white light emitting devices. In other embodiments, one or more of the light emitting devices **126** emit a colored light and/or are multicolored light emitting devices. In this application, light emitting diodes have the advantage of consuming little power for the amount of illumination provided, as compared to conventional incandescent lamps. However, it should be understood that the advantage has little significance when an external power supply **302** is used. Incandescent lamps are readily available in small packages with high intensity white light. In another embodiment, the light emitting devices **126** are incandescent lamps.

[0023] In one embodiment, a light barrier **138** is positioned normal to the glass plate **106** and between the glass plate **106** and the back sheet **108**. Figure 1 illustrates a light barrier **138** isolating the light emitted from one light emitting device **126B** from the other light emitting devices **126A**, **126C**, **126D**. In this embodiment, the isolated light emitting device **126B**, if it had an emitted color different than the other light emitting devices **126A**, **126C**, **126D**, would produce a special effect by backlighting the image **112**. In other embodiments, the light barrier **138** is positioned to produce other special effects on the image **112** by positioning the barrier **138** so as to produce shadows or to isolate the illumination of one light emitting device **126** from another light emitting device **126**. In one embodiment, the barrier **138** has surfaces that reflect the illumination from the light emitting devices **126**.

[0024] In one embodiment, the LEDs **126A**, **126B**, **126C**, **126D** are surface mount super-yellow LEDs with an intensity of 200mcd at a forward voltage of 2.5 volts and a current of 20 milliamps. In one embodiment, the LEDs **126A**, **126B**, **126C**, **126D** are secured to the glass plate **106** with an adhesive. In another embodiment, the dropping resistor **122** is secured to the glass plate **106** with an adhesive. In another embodiment, the power connector **124** is secured to the glass plate **106** with an adhesive. The adhesive provides structural strength to secure the components **122**, **124**, **126** to the glass plate **106**. One such adhesive is Loctite Chipbonder, which is a surface mount adhesive. Other adhesives are also suitable.

[0025] In one embodiment, the electrical connection of the components **122**, **124**, **126** to the conductive trace **128** is accomplished by applying a highly conductive adhesive to join the terminals of the components **122**, **124**, **126** to the conductive trace **128**. In one embodiment, the conductive trace **128** and the conductive adhesive are the same material. The highly conductive adhesive is an electrically conductive silver epoxy such as Elpox as sold by Amepox Microelectronics Ltd. Other adhesives that have a high conductivity are also suitable. In another embodiment, a highly conductive adhesive that is a polymer paste is used as a solder replacement. One such solder replacement is Eko-Solder as sold by Amepox Microelectronics Ltd. Other solder replacements are also suitable. In still another embodiment, termination areas are formed of solder paste applied to an exposed portion of the conductive trace **128**. The terminals of the components **122**, **124**, **126** are placed in conjunction with the termination areas and the solder is re-flowed, thereby forming an electrical connection between the conductive trace **128** and the components **122**, **124**, **126**.

[0026] In one embodiment, the conductive traces **128** are printed on one surface of the substrate **106**. The components **122**, **124**, **126** are then placed on land pads formed as part of the conductive traces **128**. In another embodiment, additional conductive adhesive is placed on the land pads as necessary and depending on the thickness of the printed conductive trace **128**.

[0027] Figure 3 illustrates one embodiment of the electrical connections of the backlight image system **10**. In this embodiment, a power supply **302** is connected to a power source **304**. The power supply **302** converts the voltage of the power source **304** to a DC voltage suitable for supplying power to the four series connected LEDs **126A**, **126B**, **126C**, **126D**. The dropping resistor **122** ensures that the current through the LEDs **126** is limited, which in one embodiment is a current of 20 milliamps. The power supply **302** has a cable with a power supply connector **324** that mates to the power connector **124** on the glass plate **106**.

[0028] Figure 4 illustrates another embodiment of the electrical connections of the backlight image system **10**. In this embodiment, the LEDs **126A**, **126B**, **126C**, **126D** are parallel connected, again with the dropping resistor **122** ensuring that the current through the LEDs **126** is limited. Those skilled in the art will recognize that the LEDs **126** can be wired with a combination of series and parallel connections without departing from the spirit and scope of the present invention.

[0029] Figure 5 illustrates still another embodiment of the electrical connections of the backlight image system **10**. In this embodiment, two incandescent lamps **502A**, **502B** are wired in parallel to provide illumination. Those skilled in the art will recognize that any number of incandescent lamps **502** in various series-parallel arrangements can be used without departing from the spirit and scope of the present invention.

[0030] In another embodiment, the power connector **124** on the glass plate **106** is replaced by a battery holder. In this embodiment, no external power supply **302** is used, but the power source **302** is connected directly to the conductive traces **128** on the glass plate **106**. The power source **302** in this embodiment is one or more direct current batteries.

[0031] In still another embodiment, the power source **302** is connected directly to the illumination circuit through the power supply connector **324**. In this embodiment, the power source **302** is a battery pack containing one or more

batteries. The power supply connector **324** of the battery pack **302** is plugged into the power connector **124**, thereby powering the illumination circuit.

[0032] In various other embodiments, the illumination circuit includes components that vary the illumination provided by the light emitting devices **126**, such as by switching selected light emitting devices **126** on and off, by changing the color emitted by multi-colored light emitting devices **126**, or by varying the intensity of the light emitting devices **126**.

[0033] The glass plate **106** with the lighting circuit, in one embodiment, is fabricated by first applying the conductive traces **128** to the glass plate **106**. An adhesive is then applied to the glass plate **106** at the locations of the dropping resistor **122**, the power connector **124**, and the light emitting devices **126**. The electrical components **122**, **124**, **126** are then positioned on the adhesive. The glass plate **106** is then cured in an oven.

[0034] In another embodiment, an opaque border **206** is printed around the perimeter of the glass plate **106**. The opaque border **206** hides the traces **128** and components **122**, **124**, **126** from view from the opposite surface of the glass plate **106**. The opaque border **206** is formed of an opaque ink, which, in one embodiment, is a thermosetting gloss ink from Sericol. In the embodiment with the border **206**, the border **206** is printed and cured before the traces **128** are printed, the components **122**, **124**, **126**, as necessary, are installed. In one embodiment, the opaque border **206** is approximately 1-1/2 inches in from the edge of the glass plate **106**. In other embodiments, the opaque border **206** has an inside aperture formed to illuminate all or selected portions of the image **112**.

[0035] The backlight image system **10** includes various functions. The function of forming an illumination circuit on a substrate is implemented by the conductive traces **128** cured to the plate **106** with the traces **128** electrically connecting the LEDs **126** to the dropping resistor **122**, all of which are formed or attached to the plate **106**. In another embodiment, the function of forming the illumination circuit is implemented by the conductive traces **128** cured to the plate

106 with the traces **128** electrically connecting the light emitting devices **126**, which are incandescent lamps attached to the plate **106**.

[0036] The function of supplying power to the illumination circuit is implemented, in one embodiment, by the power connector **124** attached to the plate **106** and electrically connected to the conductive traces **128** forming the illumination circuit. In another embodiment, the function of supplying power is implemented by adhering a battery holder to the plate **106** with the electrical connections for the battery holder electrically connected to the conductive traces **128** forming the illumination circuit.

[0037] The function of backlighting the image is implemented by the illumination circuit formed on the rear surface of the plate **106** with the transparent or translucent sheet **104** adjacent the opposite surface of the plate **106**. In another embodiment, the function of backlighting the image includes the back board **108** with a reflector. In still another embodiment, the function of backlighting the image includes the back board **108** with spacers **134** and a surrounding frame **102** that secures the sheet **104**, the plate **106**, and the back board **108**. The function of blocking a front view of the illumination circuit is implemented by the opaque border **206** applied to the glass plate **106** between the plate **106** and the conductive traces **128**. The opaque border **206** hides the conductive traces **128** with their associated land pads and hides the components **122**, **124**, **126** forming the illumination circuit.

[0038] From the foregoing description, it will be recognized by those skilled in the art that a backlight image system **10** has been provided. An illumination circuit is placed on a glass plate **106** positioned behind a translucent sheet **104** or other object to be illuminated. Electrical power is applied to the illumination circuit, thereby powering at least one light emitting device **126** to provide backlight illumination to the image **112**. Special effects are produced by using light barriers **138** positioned so as to direct or block the illumination from specified areas of the image **112**. Also, special affects are produced by using light emitting devices **126** with varying colors or intensity.

[0039] While the present invention has been illustrated by description of several embodiments and while the illustrative embodiments have been described in considerable detail, it is not the intention of the applicant to restrict or in any way limit the scope of the appended claims to such detail. Additional advantages and modifications will readily appear to those skilled in the art. The invention in its broader aspects is therefore not limited to the specific details, representative apparatus and methods, and illustrative examples shown and described. Accordingly, departures may be made from such details without departing from the spirit or scope of applicant's general inventive concept.